

55705'1  
Extended Abstract  
for

Flow Visualization Techniques in Wind Tunnel Tests of a Full-Scale F/A-18 Aircraft

by

\*Wendy R. Lanser, Gavin J. Botha  
tel (415) 604-3543  
fax (415) 604 - 3489  
Wendy\_Lanser@qmgate.arc.nasa.gov  
NASA Ames Research Center  
Moffett Field, CA  
and  
Kevin D. James, Mark Bennett  
Sterling Federal Systems, Inc.  
NASA Ames Research Center  
Moffett Field, CA  
and  
James P. Crowder  
X-Aero Systems, Inc.  
Seattle, Washington  
and  
Don Cooper  
San Jose State University  
San Jose, CA

Introduction

The proposed paper presents flow visualization performed during experiments conducted on a full-scale F/A-18 aircraft in the 80- by 120-Foot Wind-Tunnel at NASA Ames Research Center. The purpose of the flow-visualization experiments was to document the forebody and leading edge extension (LEX) vortex interaction along with the wing flow patterns at high angles of attack and low speed high Reynolds number conditions. This investigation used surface pressures in addition to both surface and off-surface flow visualization techniques to examine the flow field on the forebody, canopy, LEXs, and wings. The various techniques used to visualize the flow field were fluorescent tufts, flow cones treated with reflective material, smoke in combination with a laser light sheet, and a video imaging system for three-dimension vortex tracking. The flow visualization experiments were conducted over an angle of attack range from 20° to 45° and over a sideslip range from -10° to 10°. The various visualization techniques as well as the pressure distributions were used to understand the flow field structure. The results show regions of attached and separated flow on the forebody, canopy, and wings as well as the vortical flow over the leading-edge extensions. This paper will also present flow visualization comparisons with the F-18 HARV flight vehicle and small-scale oil flows on the F-18.

## Description of the Aircraft Model

A three-strut configuration was used to mount the F/A-18 aircraft in the test section (Fig. 1). The aircraft was attached to a circular crossbeam at the two main landing-gear positions. The crossbeam was then attached to the wind tunnel main struts. A tail boom assembly connected at the aircraft engine and the arresting tail hook mounts, was used to attach the aircraft to the wind tunnel tail strut. This mounting arrangement placed the crossbeam 34.5 ft above the floor of the test section.

The full-scale F/A-18 aircraft tested (Fig. 1) was a single-seat aircraft built by the McDonnell Douglas Aircraft and Northrop corporations. The F/A-18 fighter aircraft has two vertical stabilizers canted 20 deg outboard from the vertical and has leading edge extensions (LEXs) on each side of the fuselage just forward of the wing. During the wind tunnel test, the aircraft had both engines removed, the wing-tip missile launch racks mounted, and the control surfaces configured for high-angle-of-attack flight. The configuration for high angle of attack fixed the leading-edge flaps at 33° leading-edge down and the trailing-edge flaps at 0°. The horizontal tails were operated on a flight control schedule that was a function of angle of attack to maintain trimmed flight conditions. The rudders were positioned at 0° deflection.

## Experiment Description

To better understand the flow field structure being visualized time-averaged pressures were measured on the forebody, LEXs, and wings. The pressure orifices were located at five fuselage stations (FS): three circumferential rings on the radome, and two circumferential rings on the forebody. Additionally, there were three rows of pressure orifices located on each LEX and the port wing.

The laser light sheet and the smoke system were used to obtain LEX vortex burst location information. The laser light sheet was set up in the attic of the wind tunnel directly above the aircraft. The light source was positioned to bisect the smoke that was entrained into the LEX vortex providing a cross sectional view of the flow pattern. The position of the light sheet was traversed forward and aft so that the vortex burst location could be tracked. The smoke and laser images were captured by an attic mounted video camera and a 35 mm still camera, both located in front of the radome. Digital images were also recorded using a Macintosh based stereo range finding camera system. This system consisted of two attic mounted video cameras which captured synchronized two dimensional images that were used to calculate the three-dimensional path of the vortex core by means of epipolar geometry.

The on-surface flow field was captured using three-inch long fluorescent tufts that were attached to the aircraft forebody, canopy, LEX and right wing using a combination of glue and tape. To illuminate the tufts, four ultraviolet flash lamps with UV bandpass optical filters were

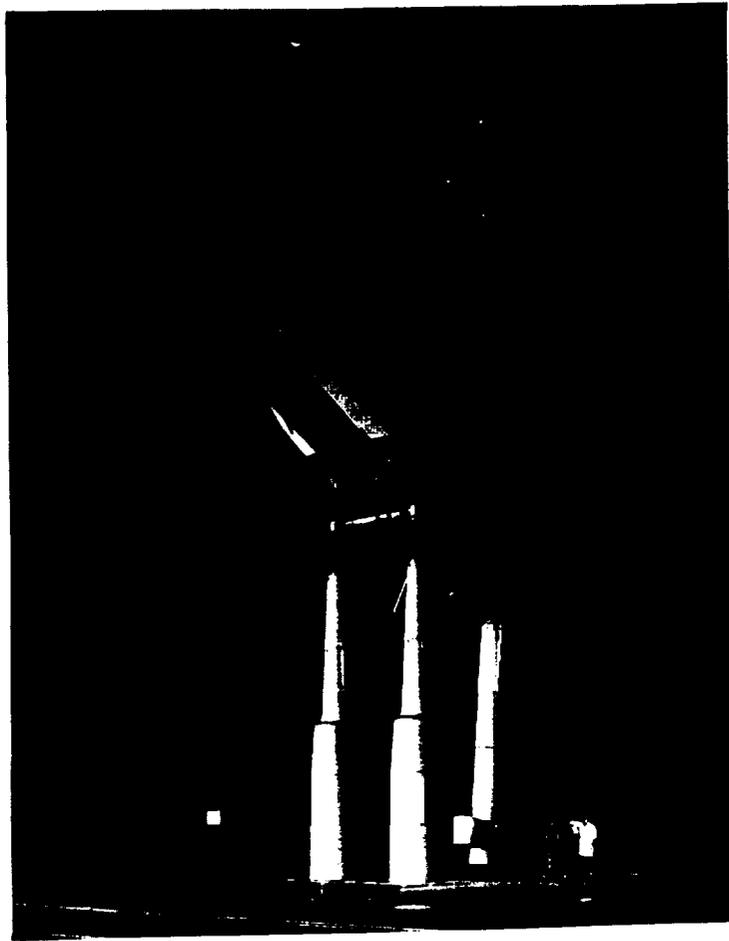


Figure 1: F/A-18 aircraft mounted in the 80x120 foot wind tunnel test section with laser light sheet.

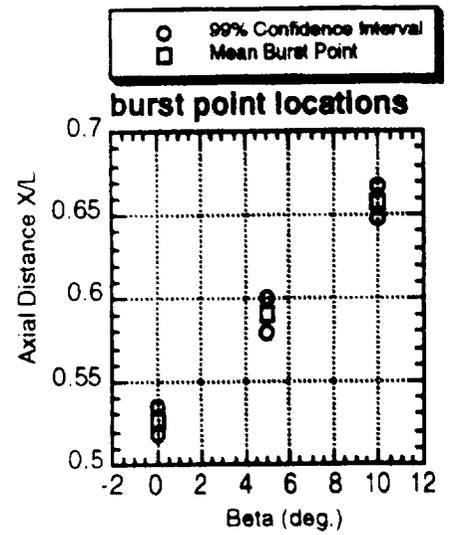
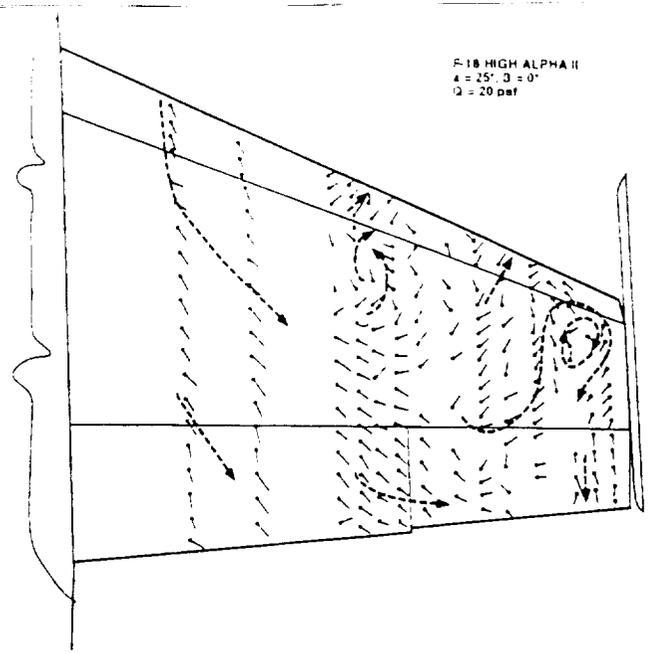
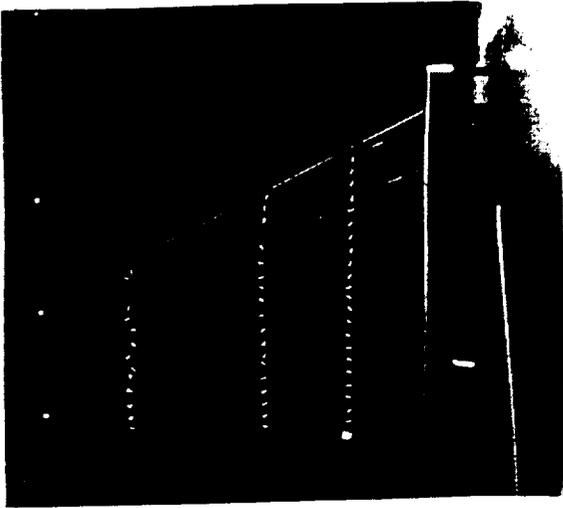


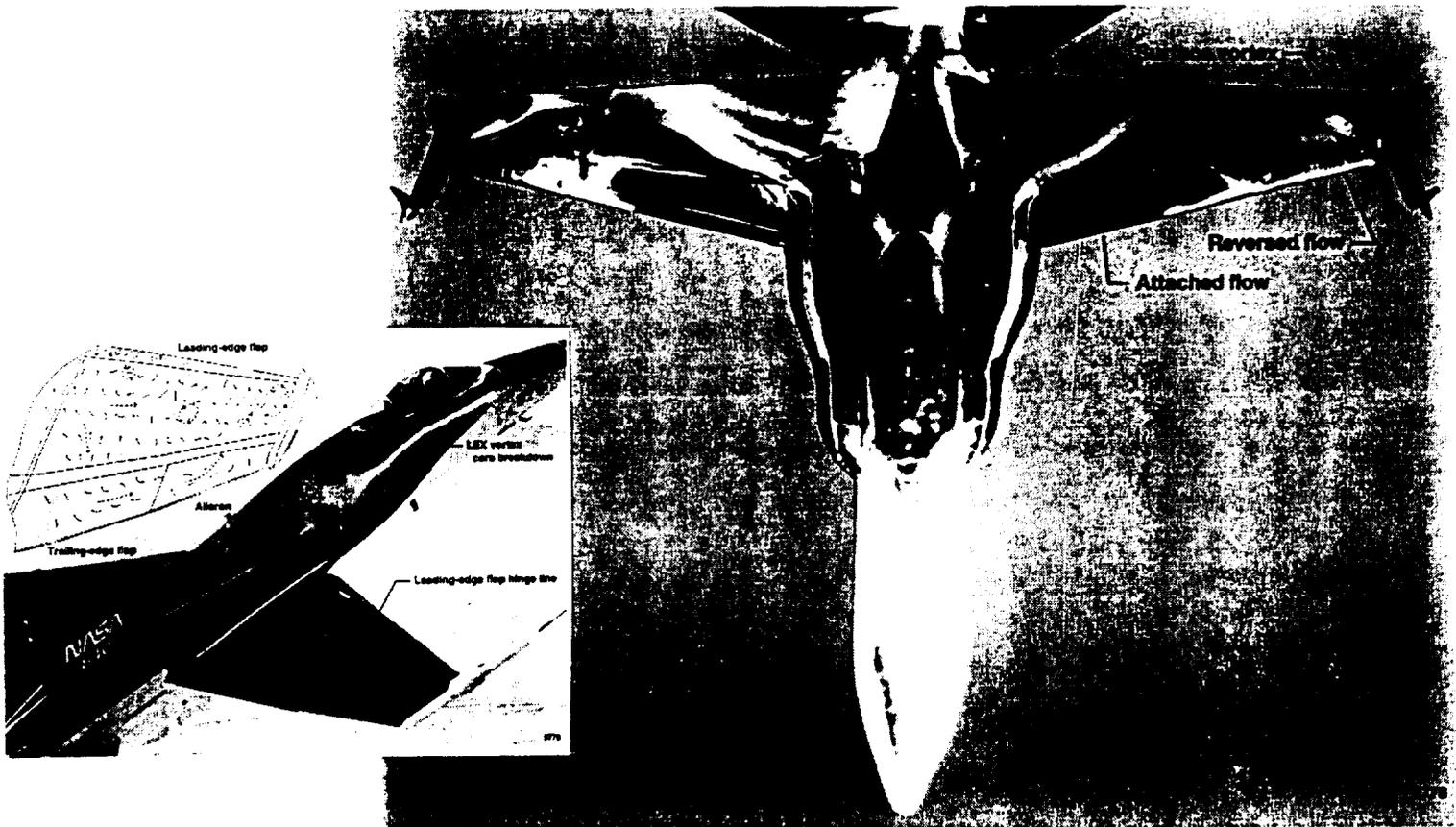
Figure 2: Vortex trajectories at 30° angle-of-attack for 3 yaw conditions superimposed on a wire frame model of the F-18.



Retro reflective flow cones at 30° angle-of-attack.

Fluorescent flow tufts at 25° angle-of-attack.

Figure 3:



Flight test flow tufts at 30° angle-of-attack

Oil flow visualization of 0.06-scale model at 25° angle-of-attack

Figure 4: